The Patent Office

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

I also certify that the attached copy of the request for grant of a Patent (Form 1/77) bears an amendment, effected by this office, following a request by the applicant and agreed to by the Comptroller-General.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed K Behen

Dated 29 August 2003

Patents Form 1/77

Patents Act 1977
(Rule 16)

THE PATENT OFFICE
H
24 AUG 2002
NEWPORT

The Patent Office
PATENTS • DESIGNS • COPYRIGHT • TRADE MARKS

1/77

The Patent Office

Cardiff Road
NEWPORT
South Wales
NP10 8QQ

Request for grant of a patent

(See the notes on the back of this form. You can also get and explanatory leaflet from the Patent Office to help you fill in this form)

24 AUG 2002

1. Your reference — **P1049.GBA**

2. Patent application number — 0219804.2
(The Patent Office will fill in this part

27AUG02 E743658-1 D02761
P01/7700 0.00-0219804.2

3. Full name, address and postcode of the or of each applicant. *(underline all surnames)*

Alstom (Switzerland) Limited
Brown Boveri Strasse 7
5401 Baden
Switzerland

Patents ADP number *(if you know it)* — 8259186004

If the applicant is a corporate body, give the country/state of its incorporation — **Switzerland**

4. Title of the invention — **TURBOCHARGER**

5. Name of your agent *(if you have one)* — ~~**LOVEN & CO**~~

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

~~**Quantum House**~~
~~**30 Tentercroft Street**~~
~~**LINCOLN**~~
~~**LN5 7DB**~~

51/77
Dargavel Lawrence Peter
Alstom Intellectual Property
Alstom Ltd
PO Box 30
Lichfield Rd Stafford ST17 4LN

4462115004

Patents ADP number *(if you know it)* — ~~**4467460003**~~

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
(a) any applicant named in part 3 is not an inventor, or
(b) there is an inventor who is not named as an applicant, or
(c) any named applicant is a corporate body
See note (d))

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	5
Claim(s)	1
Abstract	1
Drawing(s)	2 + 2 JMC

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	2
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Date **23 August 2002**

12. Name and daytime telephone number of person to contact in the United Kingdom **K J Loven (01522 801111)**

Warning
After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes
a) If you need help to fill in this form or have any questions, please contact the Patent Office on 08459 500505
b) Write your answers in capital letters using black ink or you may type them.
c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
d) If you have answered 'Yes', Patents Form 7/77 will need to be filed.
e) Once you have filled in this form you must remember to sign and date it.
f) For details of the fee and ways to pay, please contact the Patent Office.

TURBOCHARGER

Field of the Invention

This invention relates to a turbocharger and to an impeller therefor.

Background to the Invention

Turbocharger impellers are typically formed of aluminium to provide low rotational inertia with reasonable strength at a commercially-acceptable cost. Attachment of the impeller to the steel turbocharger shaft is achieved in various ways, but because of the relative weakness of aluminium and the small diameter of the shaft, it is desirable to provide the impeller with a steel insert containing a screw-threaded socket which can be threaded on to the shaft. This arrangement can take a higher torque than a connection in which the shaft is directly threaded into the aluminium body (the torque is proportional to the power transmitted across the joint, and so the impeller can be used at a higher pressure ratio than one in which there is a direct threaded connection).

Typically, such an insert is fitted into the impeller by shrink fitting; the aluminium body of the impeller is heated to expand the bore which is to receive the steel insert, while the insert is cooled, for example using liquid nitrogen, before being inserted into the bore. The resultant interference connection is restricted by the temperature to which the aluminium can be heated before its material properties are affected, and by the temperature to which the steel can be cooled.

While the arrangement described can perform satisfactorily, a problem can arise during cycling of the turbocharger from rest to full load. As the turbocharger starts to spin, the joint is affected by centrifugal forces, whereby the aluminium grows outwards away from the steel insert. This reduces the force between the insert and the impeller, and due to design constraints it has been found that this reduction tends to be greater at one end of the insert than at the other. As a result, the insert is gripped more firmly at one of its ends than at the other. The turbocharger then starts to heat up, and because of the different thermal coefficients of expansion of the aluminium and the steel, the aluminium grows axially more than the steel, causing the two metals to slide over each other, except at the location where the impeller still grips the insert firmly. On shutdown, the centrifugal stresses are removed, but the thermal stresses remain for some minutes as the

turbocharger cools. In this process, the point of grip of the changes from one end to the other, and as the turbocharger cools, the insert "walks" along the impeller.

In certain very cyclic conditions (for example fast ferry applications in high ambient temperatures), it has been observed that the impeller can move so far along the insert that turbocharger failure can occur. Although the effect can be mitigated to some degree by increasing the original interference between the components, for the reasons mentioned hereinbefore this solution is limited, and it is therefore desirable to achieve a design which ensures that the point of grip remains at the same location during the operating cycles, rather than shifting from one end of the insert to the other.

Summary of the Invention

According to the invention, there is provided a turbocharger having an impeller formed of a first material mounted on a turbocharger shaft by means of an internally-threaded insert of a material of greater strength than the first material interference fitted into the impeller, and a constraining ring of a material having a lower coefficient of thermal expansion than the first material and surrounding at least a part of that axial length of the impeller which overlies the insert.

Preferably, the impeller is formed of aluminium or an alloy thereof and the shaft, the insert and the ring are all formed of steel.

Since the ring does not expand as much as the impeller body as the turbocharger heats up, the point of grip between the impeller and the insert remains within the ring during the whole operating cycle of the turbocharger, thereby preventing the tendency of the impeller to "walk" along the insert. As a consequence, the operating life of the turbocharger can be considerably extended in comparison with the conventional turbocharger without the constraining ring.

The constraining ring can be fitted on to the impeller body by heating the ring to permit it to be slid on. Cooling then causes the ring to grip. It will be seen that it is not necessary for the ring to exert a high compressive force on the impeller body; its function is to constrain expansion of the impeller relative to the insert either due to the effects of centrifugal stresses or to thermal expansion. Indeed, it is possible for the ring to have a

slight clearance on the assembly, exerting no significant grip. It would then be sufficient to warm the ring to allow it to slip over the impeller more easily on assembly.

It has been found that an additional benefit of the use of the constraining ring is that the torque transmitting capability of the joint is increased. This has a major benefit to the rotating assembly, especially if the design is to be used in a mini turbine, where strong fault torques may be transmitted through the rotor shaft.

The invention also provides an impeller for a turbocharger, comprising a body of a first material containing an internally-threaded insert of a material of greater strength than the first material, to be screwed on to a shaft of a turbocharger, in use, the body having mounted thereon a constraining ring of a material having a lower coefficient of thermal expansion than the first material , the ring surrounding at least a part of that axial length of the impeller which overlies the insert.

Brief Description of the Drawings

In the drawings, which illustrate exemplary embodiments of the invention:

Figure 1 is a sectional elevation through a turbocharger impeller, the lower part of the Figure illustrating a conventional impeller and the upper part of the Figure illustrating an impeller in accordance with the invention; and

Figure 2 is an enlarged sectional view of a part of the impeller with another form of constraining ring fitted.

Detailed Description of the Illustrated Embodiments

Referring first to Figure 1, an aluminium impeller 1 is fitted on to a steel turbocharger shaft 2 by means of a steel insert 3. The shaft 2 is formed at its end with a first shoulder 4 surrounding a locating portion 5, and a screw-threaded portion 7 of further reduced diameter extending from the end thereof. The steel insert 3 is of generally cup-like shape, having a flange 8 around its mouth engaging against the end face 9 of the impeller 1 and in turn being engaged on its other side by the shoulder 4 on the shaft 2. The locating portion 5 of the shaft is received in the main hollow part 10 of the insert in a close, but not tight, fit. A threaded bore 11 extends through the end face 12 of the insert and engages on the screw-threaded portion 7 of the shaft. A circumferential recess 13 on the outer surface of the impeller body forms with the flange 8 of the insert 3 a groove

which can receive a sealing ring (not shown) to provide a rotating oil and pressure seal between the impeller and the casing in use. The conventional arrangement is represented by the lower half of the Figure.

The upper half of the Figure shows the addition of a constraining ring 14 around the impeller body. The constraining ring is fitted on to the body by heating the ring to cause it to expand, and then slipping it on to the impeller where, on cooling, it grips the impeller in a position overlying and surrounding a portion of the interface between the insert and the impeller. This ensures that the grip between the impeller and the insert remains sufficient throughout the operating cycle of the turbocharger of which the impeller is a part to prevent relative movement therebetween under the influence of centrifugal or thermal stresses.

Figure 2 illustrates in enlarged partially sectional view a preferred embodiment of the turbocharger impeller, in which those components which are essentially the same as in the embodiment shown in Figure 1 are given the same reference numerals and are not described again in detail. In this embodiment, the constraining ring 14 extends over substantially the length of the connection between the insert 3 and the impeller 1, and is provided with a circumferential recess 15 in the outer surface thereof which, in conjunction with an oil thrower ring 16 mounted on the insert flange, defines a groove to receive a sealing ring 17 which serves to retain lubricating oil to the shaft side of the assembly (right hand in the Figure) and compressed air to the impeller side of the assembly (left hand in the Figure). The fitting of the constraining ring 14 is carried out after the insert has been fitted into the impeller in conventional manner, as hereinbefore described. The ring 14 is slid on to the impeller at the desired position; it may be necessary to warm the ring first to facilitate this. The ring may be an interference fit or a running fit on the impeller, to constrain outward expansion thereof under thermal or centrifugal stresses, but it does not need to exert any stresses on the impeller in the start or cold state. The oil thrower ring 16 is then fitted on to the flange 8 of the insert 3 by shrink fitting, and may serve the additional function of preventing axial movement of the constraining ring when cold. The sealing ring 17 can be fitted on assembly of the shaft into the turbocharger, for example

in the manner of piston rings in an internal combustion engine. Alternatively, the sealing ring 17 is fitted before the oil thrower ring 16 is put in position.

CLAIMS

1. A turbocharger having an impeller formed of a first material mounted on a turbocharger shaft by means of an internally-threaded insert of a material of greater strength than the first material interference fitted into the impeller, and a constraining ring of a material having a lower coefficient of thermal expansion than the first material and surrounding at least a part of that axial length of the impeller which overlies the insert.

2. A turbocharger according to Claim 1, wherein the impeller is formed of aluminium or an alloy thereof and the shaft, the insert and the ring are formed of steel.

3. A turbocharger according to Claim 1 or 2, wherein the constraining ring is substantially co-extensive with the interface between the insert and the impeller body.

4. An impeller for a turbocharger, comprising a body of a first material containing an internally-threaded insert of a material of greater strength than the first material, to be screwed on to a shaft of a turbocharger, in use, the body having mounted thereon a constraining ring of a material having a lower coefficient of thermal expansion than the first material , the ring surrounding at least a part of that axial length of the impeller which overlies the insert.

5. An impeller according to Claim 4, wherein the body of the impeller is formed of aluminium or an alloy thereof and the insert and the ring are formed of steel.

6. An impeller according to Claim 4 or 5, wherein the constraining ring is substantially co-extensive with the interface between the insert and the impeller body.

7. An impeller for a turbocharger, substantially as described with reference to, or as shown in, either of the drawings.

ABSTRACT

TURBOCHARGER

A turbocharger has a shaft (2) formed of a strong material such as steel and an impeller (1) formed of a relatively weaker material such as aluminium alloy mounted on the shaft by means of an internally-threaded insert (3), for example also of steel, interference fitted into the impeller. A constraining ring (14) of a material having a lower coefficient of thermal expansion than the material of the impeller and surrounding at least a part of that axial length of the impeller which overlies the insert.

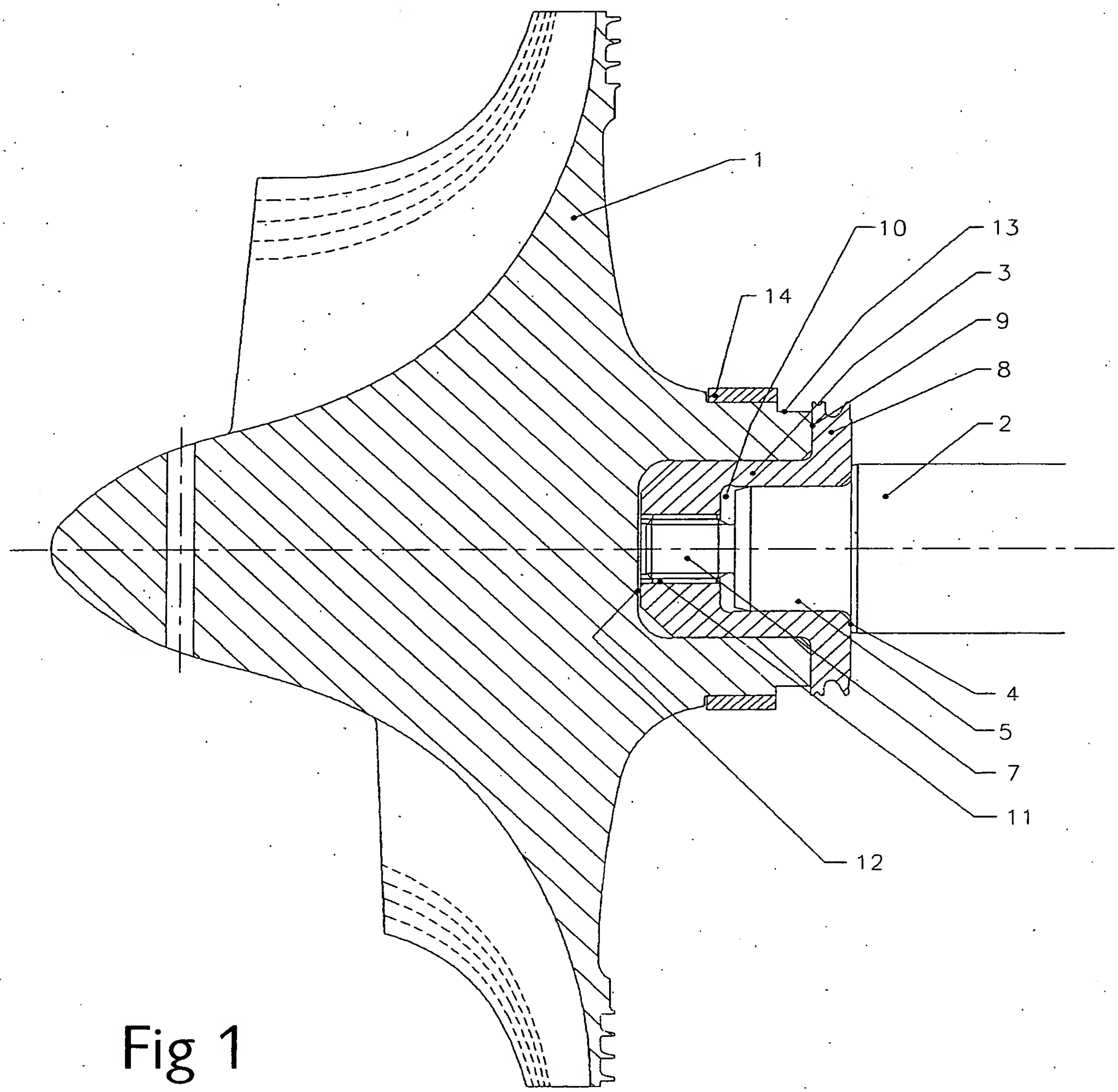

Fig 1

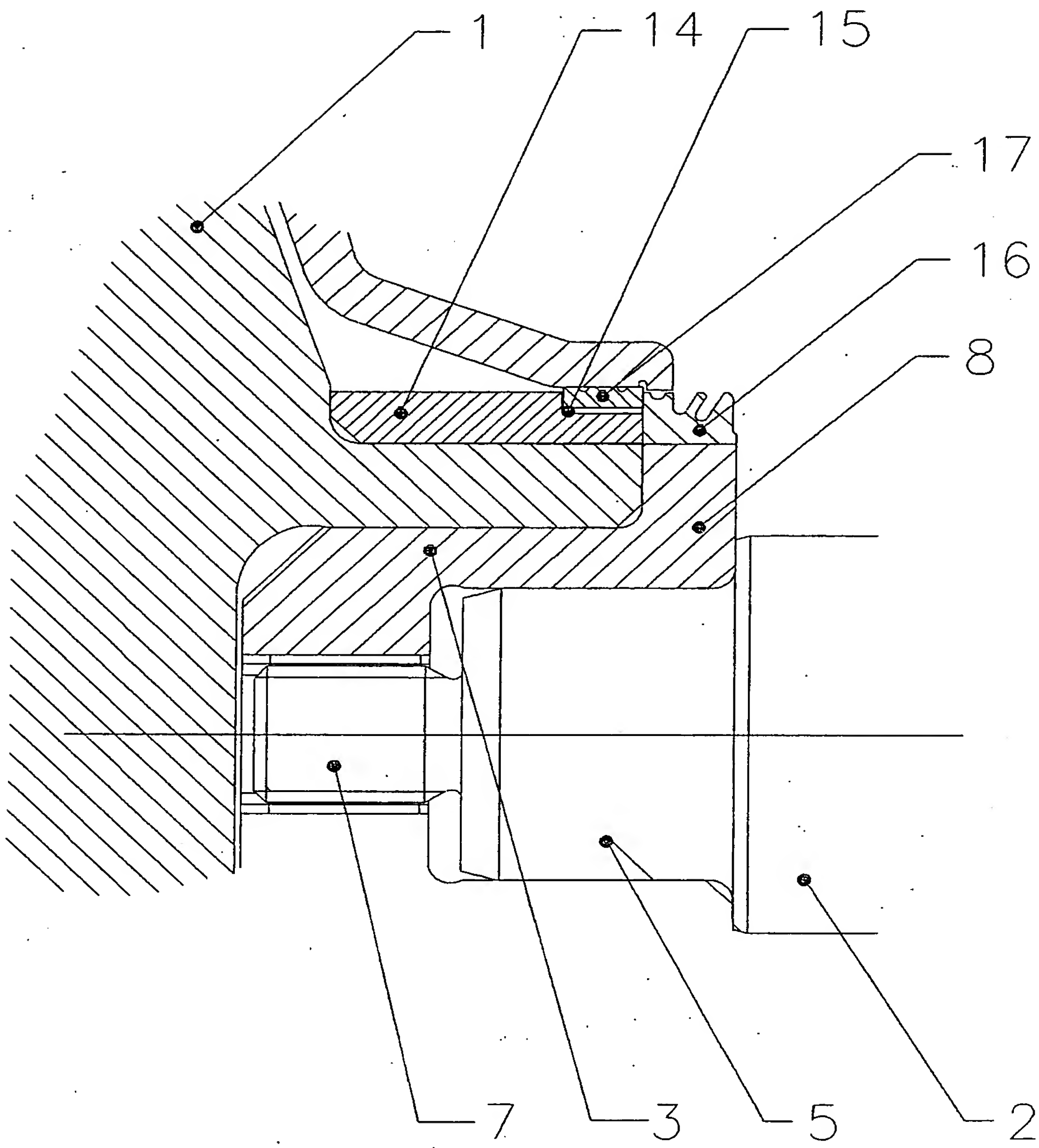

Fig 2